Vision-Based Object Detection and Distance Calculation in Indoor Autonomous Vehicles

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- BASE PAPER DETAILS :

  Simultaneous Object Detection and Distance Estimation for Indoor Autonomous Vehicles

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Article

Simultaneous Object Detection and Distance Estimation for Indoor Autonomous Vehicles

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ABSTRACT:

- This project aims to develop and test algorithms for simultaneous object detection and distance estimation in indoor autonomous vehicles.

- The proposed method will utilize YOLOv5 and its variants, YOLOv8, SSD models, and a hybrid approach using a custom dataset for training, along with the KITTI dataset for other models.

- Data augmentation and transfer learning techniques will be applied to improve model performance and adaptability.

- The evaluation will focus on comparing and assessing the models based on precision, recall, F1-score, and mAP at IoU thresholds of 0.5 and 0.95.

- The goal is to provide a reliable and cost-effective solution for accurate obstacle detection and distance estimation in indoor environments for autonomous systems.

PROBLEM STATEMENT :

- Autonomous vehicles struggle to detect and avoid obstacles inside buildings.
- Measuring the distance to obstacles accurately using regular cameras is difficult, reducing system reliability.
- LiDAR sensors are too expensive for many systems.
- Collecting labeled data for training models takes too much time.
- High-performing algorithms need costly hardware, making them less accessible.

LITERATURE REVIEW :

Sl No	Research Article	Journal, year	Methodology	Advantages	Disadvantages
1	Simultaneous Object Detection and Distance Estimation for Indoor Autonomous Vehicles	*Electronics* in 2023.	Deep learning-based object detection and distance estimation.	cost-effective object detection and distance estimation using a monocular camera, achieving high accuracy with a custom dataset by transfer learning and data augmentation.	Different YOLOv5 variants perform differently, making model selection for deployment more complex.
2	Object detection in adverse weather condition for autonomous vehicles	*Multimedia Tools and Applications* on August 22, 2023	Image enhancement using ESRGAN, detection with YOLOv7.	Autonomous vehicles aim to improve traffic flow and efficiency.	The hybrid approach may have high computational requirements and image upscaling could reduce resolution.
3	Vehicle detection and traffic density estimation using ensemble of deep learning models	*Multimedia Tools and Applications* in August 2022.	ensemble of Faster R-CNN and SSD models .	ensemble model offers improved vehicle detection and traffic density estimation results compared to the base models.	higher computational complexity and longer inference time compared to the base models of SSD and Faster R-CNN..

Sl No	Research Article	Journal ,year	Methodology	Advantages	Disadvantages
4	You Only Look Once: Unified, Real-Time Object Detection	IEEE Access in 2016	YOLO frames object detection as regression.	YOLO is fast, processes the entire image, and learns general object representations.	YOLO has lower accuracy in localizing small objects and struggles to detect multiple nearby objects.
5	Moving Object Detection With Deep CNNs	*IEEE Access* in 2020.	fine grained framework for moving object detection and identification	better performance on high-resolution video, with a 2.6x speedup using Tiny YOLOv3.	Deep learning struggles with high-resolution scenes, background subtraction is sensitive to modeling.
6	Object Detection Method Using Image and Number of Objects on Image as Label	*IEEE Access* in 2023.	reinforcement learning-based A2C approach.	The method adapts to new environments without needing bounding boxes.	It requires a pre-trained evaluation model and can't classify object types.

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SI No	Research Article	Journal, year	Methodology	Advantages	Disadvantages
7	End-to-End Object Detection with Transformers	ECCV in 2020.	DETR uses transformers for set-based detection.	DETR simplifies detection, is easy to implement, and matches Faster R-CNN performance on COCO.	lower performance on small objects and requires a longer training schedule and additional losses for optimal performance.
8	EfficientDet: Scalable and Efficient Object Detection	IEEE Access in June 2020	integrates BiFPN, compound scaling, and EfficientNet to develop EfficientDet models.	faster inference, state-of-the-art COCO accuracy, and better Pascal VOC segmentation	Prior object detectors were too computationally expensive.
9	Improved YOLOv8n for Foreign-Object Detection in Power Transmission Lines	*IEEE Access* in 2024.	Improved YOLOv8n with ECA attention mechanism and small object detection module.	Improved accuracy, fast detection speed, and high robustness	Increased complexity and reduced performance.

Sl No	Research Article	Journal ,Year	Methodology	Advantages	Disadvantages
10	Improved Vision-Based Vehicle Detection and Classification by Optimized YOLOv4	*IEEE Access* in January 2022.	Improving the YOLOv4 object detection model by incorporating an CBAM and modifying the FPN component.	Improved object detection and classification performance compared to state-of-the-art models	Limitations include training data size, fixed input size, confidence thresholding, spatial constraints, difficulty with unusual object shapes for bounding box prediction.
11	A Survey of Deep Learning-Based Object Detection Methods and Datasets for Overhead Imagery	*IEEE Access* in 2022	comprehensive survey of deep learning-based object detection methods and datasets for overhead imagery	It surveys deep learning-based object detection methods and datasets for overhead imagery, covering both satellite and aerial images.	difficulty in detecting small objects and oriented objects, which can lead to decreased detection performance.

WORK PLAN:

- Data Collection
- Data Preparation
- Create Training Dataset
- Implementation of YOLOv5-its variants,YOLOv8,SSD models and hybrid approach for Training & Testing
- Object Detection and Distance Estimation Results
- Metrics Results and Performance Analysis
- Documentation and Reporting

METHODOLOGY USED:

Data Acquisition:

- The dataset consists of the KITTI dataset and a custom indoor dataset.
- custom dataset is collected in an indoor environment, capturing different obstacle scenarios.

Data Preprocessing:

- Data augmentation techniques are applied to increase the custom dataset from 100 to 500 images using flipping, brightness adjustments, and noise addition.
- Labels are converted into the required format(YOLO and SSD) for model compatibility.

Training and Testing:

- The dataset is split into training and testing subsets.
- Pretrained YOLOv5(s, m, n and l), YOLOv8, and SSD models are trained on the KITTI dataset, while a hybrid approach is used on the custom dataset to improve object detection and distance estimation performance.

METHODOLOGY USED:

Model Architecture:

- The methodology integrates YOLOv5(s, m, n and l), YOLOv8, SSD, and a hybrid model for object detection and distance estimation.
- Distance estimation is performed using a depth estimation model, which generates a simulated depth map for calculating object distances based on detected bounding boxes.

Performance Evaluation:

- Model performance is evaluated using Precision, Recall, F1-score, and mean Average Precision (mAP) at IoU 0.5 & 0.95.
- Compare YOLOv5, YOLOv8, and SSD based metrics and performance. use confusion matrices and precision-recall curves for better visualization.

Final Model Selection:

- The best-performing model is selected based on results for object detection and distance estimation reliability, and the final model is optimized for obstacle detection and distance estimation in indoor autonomous vehicles.

DATASET DESCRIPTION:

KITTI Dataset - Version 1

- Total Files: 52.5k (**.png files**:30.0k and **.txt files**: 22.5k)
- Source : Kaggle dataset
- Image Type : .png, .jpg
- Size of image : 1242 x 375
- URL :https://www.kaggle.com/datasets/klemenko/kitti-dataset

Custom Dataset

- Total Images: 100 images initially
- Data Augmentation: Increased the dataset to 500 images using augmentation.
- Image Format: .png
- Source: Custom collected dataset

CONCLUSION :

This project aims to develop efficient algorithms for object detection and distance estimation in indoor autonomous vehicles. By using YOLOv5, YOLOv8, SSD, and hybrid models, it will provide a cost-effective solution with image datasets. Data augmentation and transfer learning will be applied to enhance model performance. The evaluation using standard metrics will ensure robust and reliable results for real-time applications.

THANK YOU